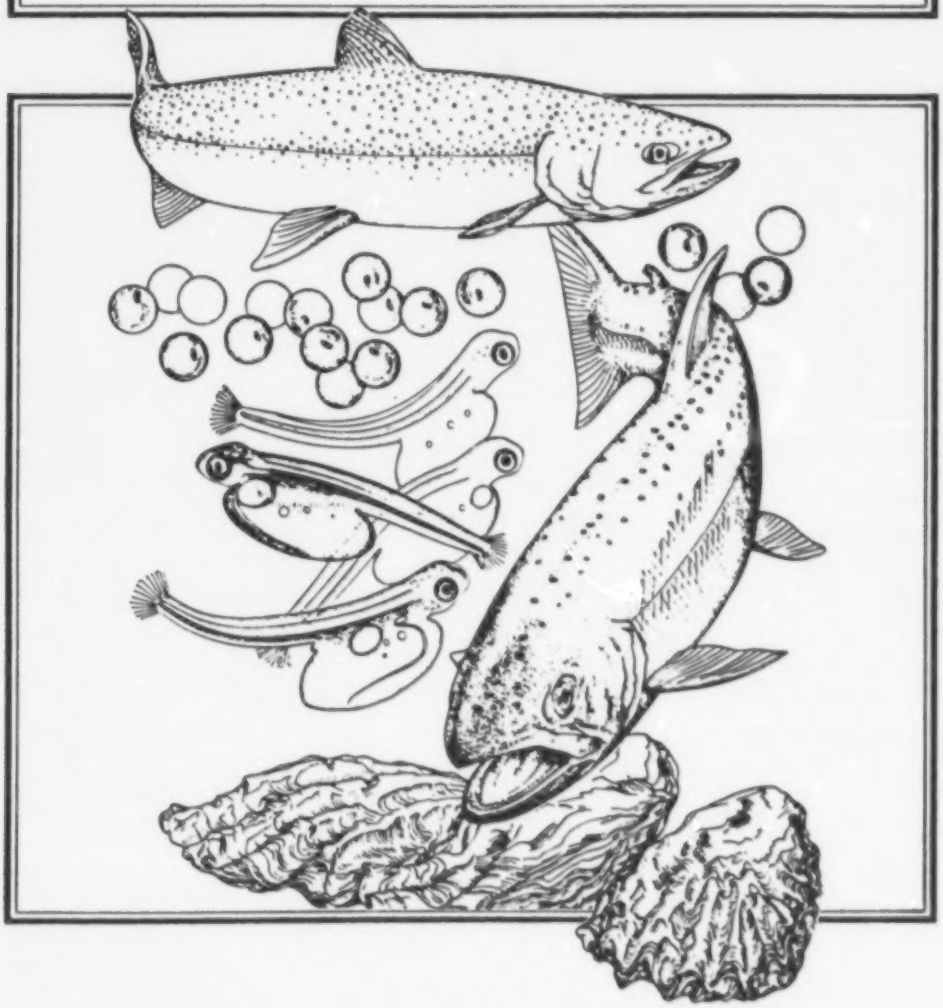
Aquaculture Industry Development Report

Arctic Charr Workshop Proceedings March 23, 1991



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ARCTIC CHARR WORKSHOP

From Securing Eggs to the Grow-out and Delivery of Product to the Customer

March 23, 1991
Chilliwack, British Columbia

Supported by:
British Columbia Ministry of Agriculture, Fisheries and Food
Aquaculture and Commercial Fisheries Branch

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Foreword

This publication is a summary of the presentations given during the Arctic Charr Workshop held at the Holiday Inn, Chilliwack, March 23, 1991. The information provided is by no means the last word on Arctic charr culture, but is meant to serve as an information source.

Special thanks are extended to the speakers, Kelvin Krieger and Lars Eriksson, for their excellent presentation and insight on Arctic charr culture.

I would like to offer a note of appreciation to the federal Department of Fisheries and Oceans, Pacific Region for their assistance in bringing Dr. Eriksson to the workshop.

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INTRODUCTION

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Distribution

The Arctic charr, Salvelinus alpinus, has the most northerly distribution of any freshwater fish. It inhabits near-shore marine waters and freshwater systems around the northern hemisphere (Figure 1). The species may be either, anadromous or "landlocked": confined to freshwater throughout it's life cycle.

Anadromous charr are found in marine waters only during the summer months, and for a period that rarely exceeds 50 days. These charr generally remain in the brackish water, within or near the estuary.

Egg Sources and Import Numbers

The Arctic charr does not occur naturally in British Columbia. Therefore, all eggs must come from an out-of-province source until broodstock are available within the province. To date, the sole supplier of eggs to the B.C. industry has been the Department of Fisheries and Ocean's (DFO) Rockwood Hatchery in Winnipeg. Although Rockwood is at present the most convenient source of certified disease-free Arctic charr eggs, it is not the only source (see discussion on Sources of Stock, page 13).

Arctic charr has been introduced across Canada for fish culture purposes. The first eggs were imported into British Columbia in 1987.

Year	Arctic Charr Egg Numbers
1987	5,000
1988	55,000
1989	72,000
1990	0
1991	7,000*

* estimated

The import figures above are small and reflect the limited number of sources for certified disease-free Arctic charr eggs. In addition, as the culture of Arctic charr is relatively new - the capacity of industry and government sources is still very limited and only small numbers of eggs are available to the aquaculturist.

Aquaculture Potential

The aquaculture potential of Arctic charr appears promising. British Columbia offers environments that are well suited for their culture, and charr offer a form of diversification for existing operations.

Additionally, charr have been identified as having high market potential. Anglers and consumers have described Arctic charr as having magnificent coloration, excellent flavor and texture.

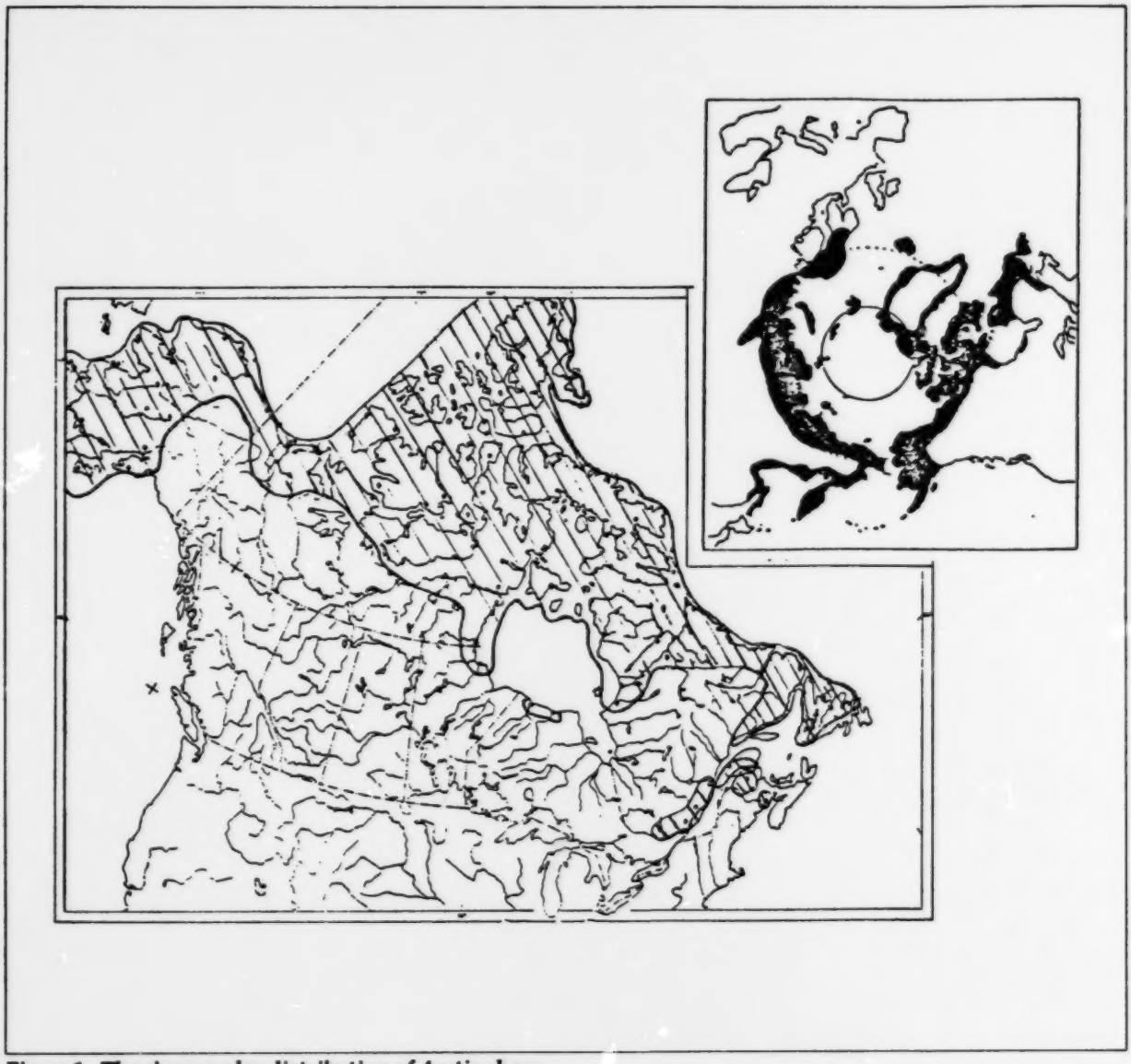
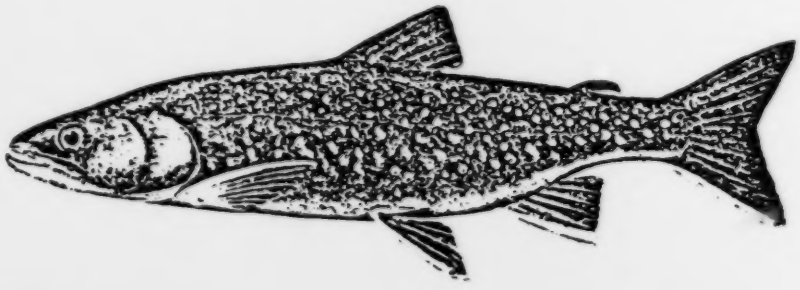


Figure 1. The circumpolar distribution of Arctic charr.



Arctic Char
Salvelinus alpinus (Linnaeus)

ARCTIC CHARR FARMING IN CANADA

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AgPro Fish Farms (formerly Elders Aqua Farms) was constructed within the old Canada Malting plant close to the center of the city of Winnipeg. It is owned by AgPro Grain Inc. which is a subsidiary of the Saskatchewan Wheat Pool.

AgPro has produced, processed and marketed Arctic charr since 1987. The rearing tanks are converted barley steep tanks and malting tables. The farm currently produces an average of 2000 pounds per month of Arctic charr with an anticipated annual production of 200,000 pounds.

The close proximity of AgPro to both the Department of Fisheries and Oceans' (DFO) Freshwater Institute and Rockwood Aquaculture Research Center was instrumental in the decision to convert the facility to a fish farm. AgPro received technical assistance and fingerlings from Rockwood through technology transfer agreements. It has since developed Arctic charr broodstock of both the Labrador and Nauyuk Lake strain.

Kelvin has been involved with aquaculture for about 10 years, including 7 years at the Rockwood Center and 2 years at AgPro.

Survey of The Industry

Stock Origins

There are two main strains of Arctic charr currently under culture in Canada: the Nauyuk Lake and the Labrador. A Norwegian strain is also cultured for research purposes at Rockwood.

The first transfer of wild stock to the DFO's Rockwood Hatchery occurred in 1978 and was obtained from Nauyuk Lake which is situated on the Kent Peninsula in the Northwest Territories.
The Labrador stock was collected from the Fraser River in Labrador in 1980, 1981 and 1984. Of all these lots, only the 1984 stock received fish health certification. Rockwood initiated a program to distribute these eggs (certified) to potential charr farmers in 1987. More than 20 sites have since received eggs.

Several sites received uncertified stocks of Nauyuk Lake and Labrador charr through special arrangements with local fish health officers. As a result, there are now Nauyuk Lake broodstock at a few sites in Manitoba (AgPro Fish Farms), Saskatchewan (Arctic Fish Company) and Yukon (Polar Sea Fisheries).

Provincial Arctic Charr Culture Activities

Newfoundland: Research and development of Arctic charr culture in Newfoundland is supported by the government and the Memorial University. Three farms are reported to carry Arctic charr stock: New Tech Charr Farms; Trinity Blue Aqua Farms (lake cage culture); and Bay D'Espoir (land-based tank facility).

Nova Scotia: Proposes to raise Arctic charr in net cages within the Bras D'Or Lakes on Cape Breton Island.

Prince Edward Island: Three Arctic charr farms are presently operating on Prince Edward Island: Integrated Aquatic Systems, Dover Fish Farm, and Brook Valley Trout Farm. Integrated Aquatic is rearing stock to 1 kg for market sale. They expect to market 30,000 pounds in 1991. Dover Fish Farm is a modern tank farm which anticipates a production of 6,000 pounds in 1991. Brook Valley has a certified disease-free hatchery and is a potential source for charr eggs.

New Brunswick: The industry in New Brunswick recently suffered a huge loss of Arctic charr fingerlings due to the use of an incorrectly prepared furunculosis vaccine. The vaccine apparently contained some live furunculosis organisms that subsequently infected the stock it was meant to protect.

There are several facilities rearing Arctic charr in New Brunswick, including farms such as; Pertill, Superior Salmon Farms and Sea Farm Canada. Pertill is presently producing 250 pounds of charr per week.

Quebec and Ontario: As a result of regulatory constraints, very little work is being conducted in Quebec on Arctic charr. Recently, a Native Band in James Bay, Quebec has expressed interest in cage culture.

Arctic charr broodstock is held by two facilities in Ontario, Alma Research Station and Coldwater Fisheries. At this time, charr has not been approved on the provincial aquaculture species list and is not permitted for sale.

Manitoba: AgPro Fish Farms, Arctic Aqua Farms and Wildwood Trout Hatchery are rearing Arctic charr for food market sale and broodstock development. AgPro sold 15,000 pounds in 1990 and anticipates production of greater than 50,000 pounds in 1991. Dressed weight of fish sold ranged from 0.5 to 3 pounds.

Saskatchewan: Arctic Fish Company produced approximately 150,000 fingerlings for market fish production in 1990. They anticipate spawning in excess of 1 million certified eggs in 1991.

Alberta and British Columbia: There is very limited production of Arctic charr in the western provinces. In British Columbia, two farms are developing Arctic charr broodstock, Sun Valley Trout Farms and Mal-Aqua-Culture. Sun Valley has been marketing a limited number of pan-size charr on a weekly basis.

Yukon: Polar Sea Fisheries rear both strains of charr, Nauyuk Lake and Labrador. In 1990, they produced 260,000 Nauyuk Lake fingerlings which they plan to raise for the 4 to 6 pound market.

Future

Collecting broodstock or eggs from the wild may be met with resistance from some government and native groups. Moreover, due to the fact that natural spawning locations for Arctic charr in Canada are remote, collection from the wild is very expensive. As a result, selective breeding programs in Canada are currently limited to the relatively small gene pool that is now being cultured. However, the Newfoundland government does have plans to carry out collection trips to a number of natural charr spawning sites in Labrador.

There are presently few eggs available to fish farmers in Canada. Perhaps future efforts will be directed at accessing charr eggs from countries such as Sweden or Iceland.

Canadian Experience With Arctic Charr Culture

Brood Stock

Strains: The Nauyuk Lake strain matures in 4 to 5 years. Its spawning season is compressed and generally occurs in 3 to 4 weeks from late August to mid-September. On average, a female produces 2000, 5 mm-eggs. Nauyuk Lake strains are not widely distributed as the federal government stock has not been certified: only a few commercial farms presently hold stock.

The Labrador strain matures in 3 to 4 years. Spawning is usually not compressed and may occur from October through to March. The Labrador strain has a high average fecundity of 4,000 to 5,000 eggs per female with an average egg size between 4.5 to 5 mm. The strain is more widespread throughout Canada than the Nauyuk Lake stock.

The Norwegian strain matures at 3 years. An early spawner (late September), the Norwegian strain produces a small egg of 4 to 4.5 mm. This strain is limited to research only.

Broodstock Feed: Jo-Anne Tabachek, from the Freshwater Institute, DFO is developing a broodstock feed. The feed has a high lipid content (17%) with added vitamin C (1000 mg per kg) and added vitamin E (600 mg per kg). This feed is currently being tested under field and experimental conditions.

Temperature: At the AgPro Fish Farms, broodstock are exposed to a seasonal temperature cycle that reaches a high of 11 oC in the summer and a low of 7 oC in the winter. The experience at Rockwood suggested that for the Nauyuk Lake strain a year-round temperature of 7 oC produced broodstock with the best spawning success. Some locations in the Maritimes have done well with their spawning of Labrador charr where the water temperature during the spawning season drops down to a couple degrees above freezing.

Light: Although the Nauyuk Lake, Norwegian and Labrador strains originate at different latitudes: 68, 61, and 56 degrees N, respectively, their spawning periods when cultured at different latitudes are similar to those in the wild.

The Labrador charr are known for their extended spawning season when reared indoors. However, the experience of P.E.I. and B.C. farmers has been that charr will have a shorter, more compressed spawning season when reared outdoors. At Rockwood, it has also been demonstrated that Labrador charr reared indoors under artificial light achieve a more natural, shorter spawning period if the day length is reduced quickly as the spawning period approaches.

Spawning: The Arctic charr female can be successfully spawned for 3 to 4 years and the spawning technique is similar to that used for other salmonids. Charr should be checked more frequently than rainbow trout as there appears to be a very narrow window of opportunity to achieve high survival rates. Therefore, fish should be checked for ripeness on a weekly basis (minimum). Four days following spawning the broodstock should be re-stripped to prevent blockages resulting from egg shells. To ensure a high fertilization rate AgPro staff spawn each female into separate bowls, seven males are pooled and the mixed milt distributed between 4 females.

Preliminary studies at the Prince Edward Island Vet. College on spawning induction with Ovaprim have yielded promising results. Following induction, survival rate to first feeding was 75%.

Incubation

Eggs should be incubated at temperatures between 4 and 8 oC. Incubators suitable for other salmonids work equally well with Arctic charr. Formalin and/or malachite green may be added to the incubation system to treat or minimize fungal infections. At 6 to 7 oC the eggs will take 40 days to eye-up, 80 days to hatch and 120 days to first feeding.

Early Survival

The hatching and first feeding stages are the most difficult in terms of success with survival. At AgPro and Rockwood, the experience with charr has been that the fertilization rates are generally high but survival to the eyed egg stage may be variable. On average, survival to the eyed egg stage is lower with charr than with rainbow trout. Micro eyes and premature hatching result in significant mortality. A batch of eggs with low survival to the eyed egg stage also tends to have a poor hatching rate and an increased incidence of deformities. An overall survival of 35% from green egg to fingerling is considered good for Arctic charr culture.

To improve survival the incubation temperature should be increased to 9-10 oC at first feeding (Figure 2).

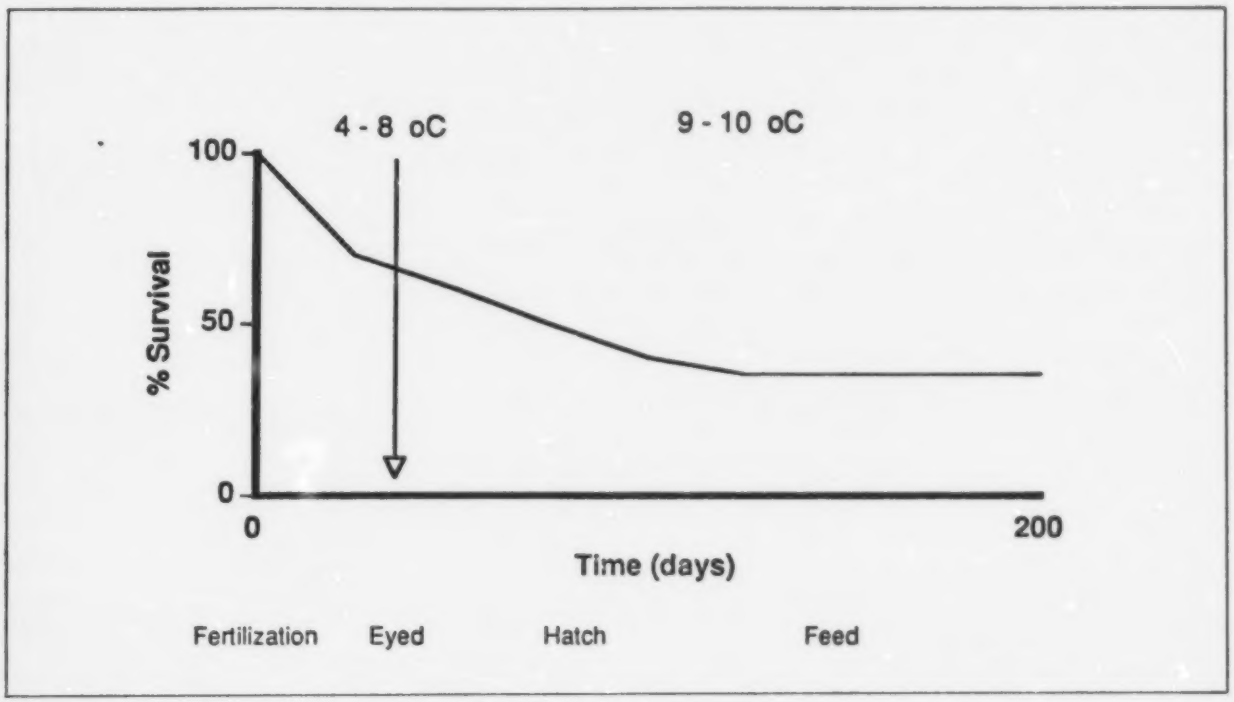

Figure 2. Conceptual early survival curve of Arctic charr and recommended temperature regime for the development stages (based on experience with charr).

Early Rearing

Feeding techniques: First feeding should begin 2 weeks before the yolk-sac is absorbed; while the fry are still sitting on the bottom of the tank. Swim-up times are variable within any particular spawning lot.

If possible the temperature should be raised gradually at this time and to avoid gill problems and other complications the tank should be kept clean. AgPro uses Bio-Diet semi-moist starter (#1 and #2). Semi-moist starter was shown to improve survival at Rockwood when compared to dry starter feed.

The effect of light: Some farms have found that the charr are "afraid" of the dark and tend to clump together at night. To prevent this "clumping" behavior the farm operators keep the facilities lighted and may continue feeding throughout the 24 hour period. The light should be kept dim to reduce shadows as charr will tend to congregate in the darker areas.

Growout

Density: The optimum density appears to range from 40 to 60 kg per m3 and will continue to grow well at densities as high as 90 kg/m3. In contrast to other salmonids this density promotes good growth and results in little fin erosion. A reduced growth rate has been observed at densities less than 30 kg per m3.

When considering rearing densities the producer must take into account safety (ie. high densities enable a limited response time to system failure), system operation (e.g. removal of waste solids), and efficiency of production and operations.

Temperature requirements: The optimum temperature for growth is between 10 to 13 oC; 18 oC is often lethal.

Growth rates level off from 10 to 13 oC and drop rapidly at higher temperatures. Rainbow trout out-perform charr above 13 oC, both have similar performance at 10 to 13 oC, and charr out-perform trout at temperatures below 10 oC.

Commercial feed: The protein and lipid requirements of Arctic charr are intermediate between the levels found in most trout and salmon feeds. The optimum levels for charr were determined by J. Tabachek, Freshwater Institute to be 17% lipid and 44% protein. Most charr farmers in Canada are presently using a trout or salmon feed. Recently a new feed, containing 18% oils and 45% protein has become available. This feed contains 65 ppm astaxanthin when ordered with pigment. AgPro has used trout feed with 40 ppm pigment in a ratio of 85% astaxanthin and 15% canthaxanthin with good results.

Charr will boil at the surface when feeding but are more inclined to pick feed off the bottom of the tank. Feed conversion rates are similar to trout.

Other factors affecting growout: Arctic charr tend to have variable growth, even within families. The variable growth rates can be accommodated by continually cropping, and removing the larger individuals for market sale. There may be some fish within the population that are runts and never reach marketable size.

During the early growth phase the Labrador strain may have equal or better growth than the Nauyuk Lake strain. However, the Labrador strain tends to have a greater proportion of precocious males. Growth of the Labrador strain drops dramatically as the fish approaches maturity. Therefore, the Nauyuk strain may be more suitable for rearing large market fish as it matures at a later age.

Arctic charr require high dissolved oxygen levels similar to rainbow trout.

Studies conducted at the Huntsman Marine Laboratory (N.B.) indicate that the Labrador strain has greater tolerance for salt than the Nauyuk Lake strain.

Disease

AgPro staff have not experienced or witnessed many problems arising from disease. Problems that have arisen at some locations which raise charr include: swim bladder stress syndrome, sunburn, spawning rash, furunculosis, proliferative kidney disease (PKD) and bacterial kidney disease (BKD).

Spawners are particularly prone to handling stress and fungal skin infections may occur after handling.

Arctic Charr Marketing at Agpro

Food Market

AgPro Fish Farms have been selling 1,000 to 2,000 pounds of pan-size, 10-ounce fish on a monthly basis since January 1990. The product is generally shipped fresh in 10 or 50 pound boxes and list for $5.00/pound wholesale. Some of the production is sold directly to local Winnipeg restaurants for $5.75/pound. The wholesale price for a 6-7 ounce fillet is $6.90/pound. Presently AgPro's primary market is the prairie provinces.

Recently, Iceland has been exporting 1-2 and 2-4 pound Arctic charr into Eastern Canada at a wholesale price of $4.50 per pound F.O.B. Toronto and Montreal. Iceland is currently producing approximately 50 to 100 tonnes per year, primarily in land-based tanks.

AgPro has found that there is a limited market for pan-size charr and are considering marketing a larger product. Polar Sea Fisheries is presently receiving a premium for red-fleshed Nauyuk Lake in the 4 to 6 pound range. The Arctic Fish Company is pursuing marketing of value-added charr products.

ARCTIC CHARR FARMING IN SWEDEN

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Department of Aquaculture
Box 1457, S-901 24 Umea
Sweden

The Department of Aquaculture at the University of Agricultural Sciences was founded in 1987. At this time the department assumed responsibility for a research program that was initiated by the University of Umea in 1982. Research programs focus on salmon, rainbow trout and Arctic charr. Much of the research is directed towards behavioral ecology and physiology, rearing technologies, feeding strategies, genetics and disease.

Stock Selection and Selective Breeding

In Sweden, Arctic charr is classified as one of three types: large (or predatory), normal or dwarf charr. After completing a study comparing the tree types, the University focused its research efforts on the large charr, which presently reaches a maximum weight of 10 kg. The F-charr reaches a weight of 2 to 3 kg, whereas the dwarf does not exceed a maximum of 1 kg.

In 1984, the scientists within the research group initiated a selection program to improve the performance of Arctic charr. The program employs a combination of mass selection and family selection techniques (Figure 3). Selection of parents is based on characters such as growth and maturation. Combination methods often use individual selection within superior families. Traits are weighted (indexed) according to their value to the industry.

To date, the program has recognized an improvement in stock performance of 20% per generation. Results have indicated that many of the traits selected for in Arctic charr tend to have higher heritability (0.4) than the same traits in rainbow trout (0.3).

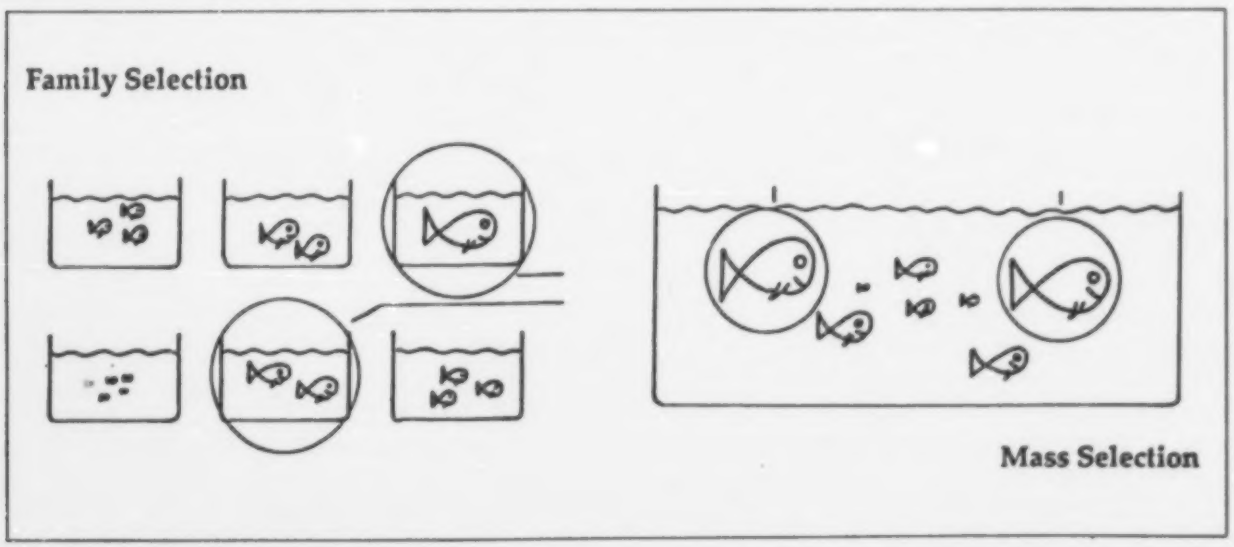
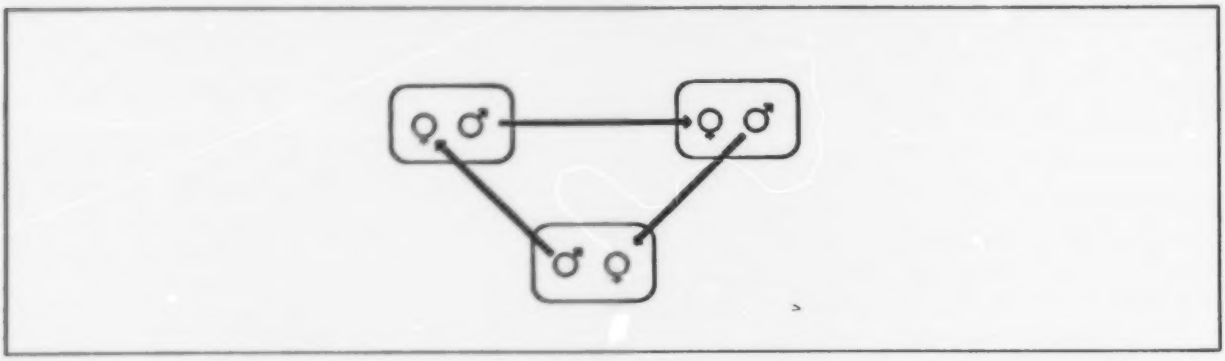


Figure 3. The mass selection technique employs the selection of individuals from a population based on specific performance criteria, whereas family selection involves the selection of families based on the mean of their performance.

Simple breeding programs may be applied on-farm to minimize the risks of inbreeding. The diagram below describes a simple, but effective strategy. This strategy prevents the sibling crosses and, in combination with mass selection can reach :



Swedish Experience With Arctic Charr Culture

Optimal temperatures for charr culture are as follows:

Egg development	4-6 oC
Hatching and alevins	6-8 oC
Start feeding	7-10 oC
Growth rates	10-14 oC

The start of feeding is more difficult than in salmon culture because of the small initial size of the alevin (0.07 grams as compared to 0.25 grams for salmon alevins) and the large variations in individual development. As the alevins are very small the culturist must be careful to select the appropriate size of food particles and ensure a good water supply and a clean rearing environment in order to minimize the number of pinheads and gill disease problems.

Once feeding, the fry are easier to culture than salmon. Their densities can be kept relatively high - 6,000 to 10,000 fry per m2. The increased demands on space can be met by increasing the water level in the rearing tank, however, care must be taken to ensure that the tanks are kept clean.

Although the nutritional requirements of charr appear to be similar to rainbow trout, it has been observed that charr are sensitive to levels of carbohydrate greater than 15%.

The growth rate of Arctic charr is density and temperature dependent. No adverse effects have been documented when charr are held at densities of about 75 kg fish per m3 rearing space. At low temperatures charr significantly out-perform rainbow trout (Figure 4). The optimal temperature for charr ranges from 10 to 13 oC and growth rate drops rapidly at temperatures greater than 14 oC. Temperatures of 20 oC and above are often lethal.

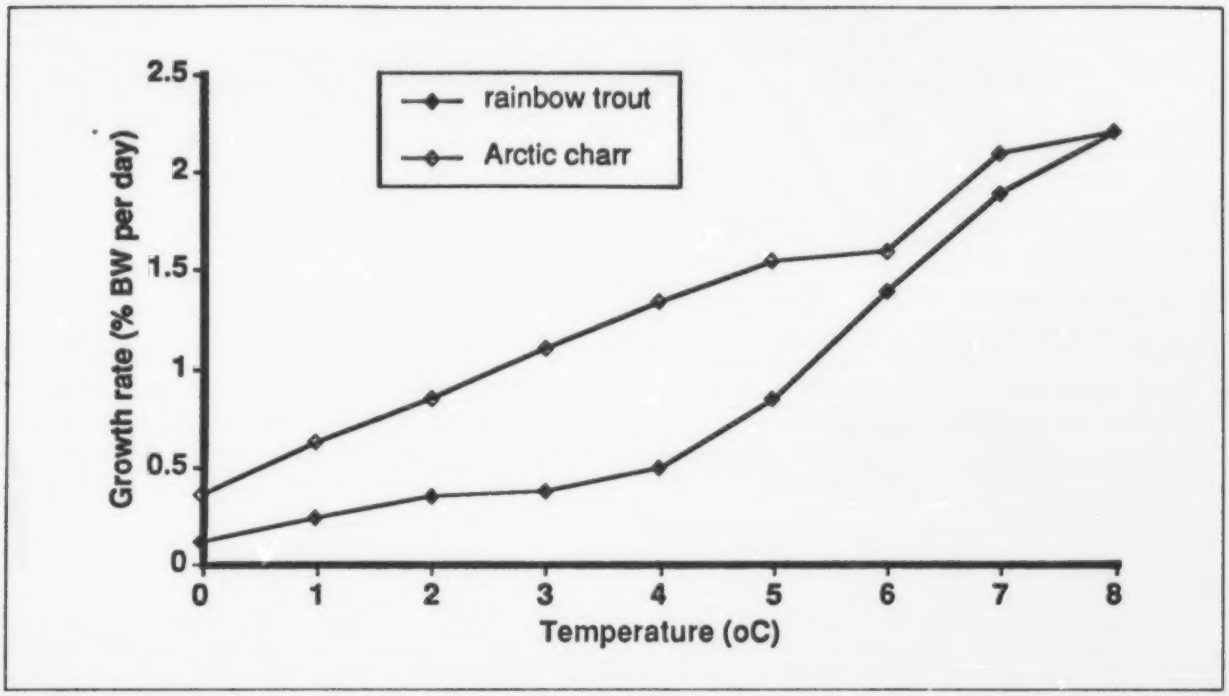


Figure 4. The growth rate, expressed as a percent (%) of body weight per day of 100-gram rainbow trout and Arctic charr at temperatures from 0 to 8 oC.

General Experiences in Commercial Farming Trials (Sweden)

Groundwater-fed, land-based farms: The growth rates and production levels of Arctic charr are good. Feed conversion rates (FCR) range from 1.2 to 1.5 kg dry feed per kg fish produced. Improved FCR should be achieved through the development of more appropriate feeding technology.

Net-pen farms: Growth rates and production levels do not meet expectations. Feed conversion rates are low at 1.8 to 3.0 kg dry feed per kg fish. The low FCR are not surprising as Arctic charr tend to take up about 40% of their feed off the bottom. In net-pens, where the feed is lost through the net bottom, this feeding behavior presents a problem. As a result of variable FCR and access to feed, there tends to be a huge size variation which demands more frequent grading than in the land-based farm.

In general: Fish less than 300-400 grams tend to have a pale flesh color. Production costs are generally 30% to 50% higher than in rainbow trout. Market prices are affected by general changes in the salmon and trout retail market. Prices for eyed eggs range from $0.05-$0.07 per egg.

Summary: Advantages over rainbow trout

1. Once feeding, charr are easier to handle and not particularly sensitive to water quality (pH, turbidity, CO2 and NH3), with the exception of dissolved oxygen levels and temperature.
2. Can be reared "by volume" rather than "by area". Charr tend to make use of the entire rearing space by distributing throughout the tank. Their growth performance is positively affected by densities up to at least 80 kg per m3.
3. Comparatively good growth at low temperatures (0-5 oC).
4. Demonstrated high heritability of growth and maturation traits. Good potential for selecting for external features, flesh quality and coloration, and for disease resistance.
5. Sizes preferred by the market require a short rearing cycle.
6. Body-form and skin texture are excellent for automatic processing.
7. Good market potential.

Disadvantages

1. Sensitive to temperatures above 15 oC.
2. Start of feeding difficult.
3. Charr often adapt a "slow" feeding tactic and tend to bottom feed.
4. Sensitive to disease such as: furunculosis, vibriosis and BKD. Charr are particularly susceptible to fungal infections at the time of sexual maturation.
5. Variable growth performance and quality.
6. Variable success with broodstock and egg quality.

Marketing Artic Charr in Sweden

In Sweden, charr is marketed dressed head-on (150 gram to 1.5 kg), fillets (75-200 grams) and smoked (150 grams to 1.5 kg). Marketing trials have revealed that the individual consumer requires a smaller sized product than do the restaurants. In general, the consumer who wishes to purchase a whole, dressed charr prefers a size of 150 grams and greater. For home preparation the consumer prefers a 100-200 gram fillet or a 400-800 gram smoked charr. In comparison, the restaurants prefer a 90-120 gram fillet and a 700 gram to 1.5 kg smoked product.

Farm-gate prices for whole, bled char range from Can$2.30 to $3.20 per pound. The market price for fresh dressed, head-on product is Can $4.50 to $6.80 per pound. Fillets receive a market price of Can$6.80 to $9.90 per pound and smoked product Can$5.40 to $9.00. Frozen product is usually sold 20% below prices for fresh product.

The average dress-out yield is 88% to 89%. The average yield after filleting is 50% to 60% of the round weight.

Arctic charr lends itself well to machine filleting due to its body form and skin texture.

BRINGING ARCTIC CHARR TO YOUR FARM

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Regulations: Purpose

There is a certain degree of risk involved in introducing any non-indigenous species into a water system. New species, perhaps because of some recreational or commercial interest are from time to time deliberately transferred to new areas. This is generally accomplished in a well controlled manner and to areas where research indicates the adverse impacts will be minimal.

There is no reason why the aquaculture industry in British Columbia can not diversify and rear non-indigenous fish species. However, efforts must be made to ensure that the new species do not escape and establish viable populations. Accidental escapes can result in reduction or eradication of natural fish stocks: indirectly, due to competition for food, rearing habitat and spawning ground; or directly by preying upon juvenile fish. Efforts must also be directed toward preventing the introduction of new diseases or parasites that might endanger the natural fish stocks.

There are three principle methods employed to address these concerns.

- Control the location of imported species - certain sensitive areas are considered unacceptable for rearing of particular species due to other resource considerations.
- Screen the effluent streams to reduce the incidence of escape.
- Control imports - only eggs from certified disease free sources may enter British Columbia.

Importation of Arctic Charr Eggs

Importation of Arctic charr is generally limited to fertilized eggs. Fry/fingerlings must be purchased from a local grower. In order to import eggs for commercial purposes a farmer must:

(1) Obtain a Commercial Aquaculture License from the Ministry of Agriculture, Fisheries and Food that specifically includes Arctic charr.

Ministry of Agriculture, Fisheries and Food
Aquaculture and Commercial Fisheries Branch
808 Douglas St.
Victoria, B.C.
V8W 2Z7 (604) 387-1166

(2) Obtain from the source facility a copy of its certification confirming it's disease-free status.
(3) Contact the Fish Health Officer (DFO or MoE) and forward to him the proof of certification and number of eggs you wish to import. The Fish Health Officer may require that the first generation eggs and fingerlings be kept in quarantine.

Fish Health Officer
Department of Fisheries and Oceans
Pacific Biological Station
Hammond Bay Road
Nanaimo, B.C.
V9R 5K6 (604) 756-7033

Obtaining Fingerlings

It is unlikely that approval would be received for importing any stage other than eggs, therefore, fingerlings must be purchased from farms within British Columbia. In order to take delivery of Arctic charr for commercial purposes the site must first obtain a valid Commercial Aquaculture License that specifically includes Arctic charr.

To minimize risks of inadvertently transfering a fish disease or introducing a new species to an area, the movement of fish between aquaculture sites is regulated. A "Form A Transfer License" is automatically issued to the farmer along with the Commercial Aquaculture License. This allows the farmer to move fish within certain boundaries providing the fish and the facilities meet specific conditions (as outlined on the License). If these conditions are not met then separate application must to made to the Transplant Committee for special approval to move fish. This is then covered on the "Form B Transfer License". The Transplant Committee is a federal/ provincial body that governs the movement of fish within British Columbia.

If you have any questions relating to the above, please contact:

Ministry of Agriculture, Fisheries and Food
Aquaculture and Commercial Fisheries Branch
808 Douglas St., Victoria, B.C. V8W 2Z7

Sources of Stock

One of the major constraints to the development of the industry is the limited availability of certified disease-free broodstock and eggs.

This may benefit the industry in the long run as industry capacity is forced to increase slowly and hopefully in concert with a market development program and improved production technology.

To assist industry DFO has developed a program to enable the transfer of technology into the private sector. The program provides a way of introducing the results of government research to the aquaculture industry by providing assistance, information and stocks of certified eggs. These aquaculture agreements (Appendix I) were designed to establish private commercial charr broodstock as well as to provide the necessary technical information to farm charr (Appendix II).

Potential sources of certified disease-free Arctic charr eggs include the following facilities:

Huntsman Marine Science Center
Brandy Cove
St. Andrews, NB
E0G 2X0
Contact: Dr. John Allen, Director, (506) 529-8895

Fisheries and Oceans Canada Freshwater Institute
501 University Cresent
Winnipeg, MB
R3T 2N6
Contact: Brian Souter, Aquac. Coordinator, (204) 983-6285

AgPro Fish Farms
1051 Coulter Ave.
Winnipeg, MB
R3E 0X9
Contact: Jim Brynes, (204) 783-3390

Arctic Fish Company Inc.
Box 250
Waldheim, SK
S0K 4R0
Contact: Keith Derksen, (306) 945-2200 FAX: (306) 945-5512

McNabb Trout Hatchery
RR#5
Saskatoon, SK
S7K 3J8
Contact: (306) 934-6557

Brook Valley Trout Farm
Prince Edward Island
Contact: Sephert Dixon

Water Resources

The quantity and quality of your water source is extremely important when considering fish culture. Prior to using a water source, the water quality must be tested to ensure its suitability for fish rearing purposes.

Arctic charr are particularly well suited for growth in water temperatures of 10-13 oC (or less). The optimal water source would be groundwater for the following reasons:

- B.C. groundwater tends to be cold, with an average temperature of 6-10 oC;
- relatively constant supply;
- fairly constant year-round temperature, depending on the depth of the aquifer; and
- generally pathogen-free water.

The Ministry of Environment (MoE), Water Management Branch is an invaluable contact to growers wishing to develop their groundwater resource or to locate an area with groundwater potential. Contact the local MoE office for specific information on:

- developing the groundwater resource;
- ground water potential maps;
- private well and observation well location maps with data summary sheets (providing well depth, yield, and depth to water);
- water chemistry information. All water quality data is submitted on a voluntary basis; and
- information on testing water quality.

Marketing

A recent study was conducted by View-West Marketing on the market potential for a variety of freshwater aquaculture products. This report describes Arctic charr as having high market potential, particularly in the restaurant trade. The report adds that charr is a virtual unknown in British Columbia and the western United States and therefore effort must be directed towards market development.

A representative of Overwaitea Foods suggests that, "Any new seafood product must first make its name in the food service sector before it becomes profitable for the retail sector to carry it". However, before a producer plans to supply the food service sector (restaurants) they must be prepared to meet some stringent demands:

- reliable supply;
- stable price;
- consistent product quality;
- portion control; and
- a preference for fresh product.

Aquaculturists are often inclined to start exploring potential markets only after they are ready to sell fish. A common comment may be: "Here's the fish. We've produced it. Now what do we do with it?". Unfortunately, to begin with the marketing problem at the farm gate is often too late. The best way of avoiding potential difficulties selling product is to follow a simple strategy such as:

- Find out what the consumer wants.
  Never presuppose consumer demands. Based on consumer surveys, clearly define the product form and develop a well-organized marketing plan.
- Produce it.
- Sell it to them.

An aquaculturist's job doesn't begin and end in producing something. Rather, the starting point is finding out what potential customers demand, the middle part is growing it, and the pay-off comes from seeing that it reaches the customer as they like it.

Arctic charr production

When marketing and developing a market, it is important to be aware of competition in the market-place:

- The current production of Arctic charr in British Columbia is very small - with only minor production from the Fraser Valley.
- International and national aquaculture production (tonnes) of Arctic charr.

Year	1985	1988	1991*
Sweden	30	120	200
# Farms	10	20	10
Norway	-	-	300
Iceland	–	–	100
Canada	–	–	100
# Farms	–	–	18

* estimated

- The Canadian commercial fishery is centered in Labrador and in the Northwest Territories. Combined, these two fisheries landed 159 tonnes in 1988. The fisheries do not overlap and, with one exception, products are sold in the central Canada marketplace.

The Labrador fishery is selling product in the 2-5 pound range, whereas the Northwest Territories fishery sells a high percentage of 6-7 pound charr.

The commercial fisheries has recognized that the annual landings are steadily declining, likely due to overfishing and a reduction in landed weight.

APPENDIX I
Additional Reading: Arctic Charr Culture

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Tabachek J. 1989. Arctic charr culture. In: Water Management for Trout Production and Arctic Charr Culture. Summary of Workshop Proceedings. Langley B.C., Sept. 10 1988. British Columbia Ministry of Agriculture and Fisheries. pp. 29-36.

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APPENDIX II

Generic Draft Copy
July 15, 1991

JOINT DEPARTMENT OF FISHERIES & OCEANS - PRIVATE SECTOR

TECHNOLOGY TRANSFER AGREEMENT

TERMS OF REFERENCE

1. PARTIES TO THE AGREEMENT

a. Department of Fisheries and Oceans (referred to herein as DFO)

DFO Central and Arctic Region
Freshwater Institute
501 University Crescent
Winnipeg, Manitoba R3T 2N6

b. Client ... (referred to herein as The Client)

2. TITLE OF PROJECT

3. DESCRIPTION OF PROJECT

a. Objective:
This section should contain the following information about the client:
- type of facility
- objective if the client in the production of Arctic charr ie. production of eggs, fingerlings or market-sized fish
- recognized support from governments or other agencies
- type of technology that the client is requesting from DFO in terms of information, advice, eggs or fish, etc.

As a component of its mandate, DFO has a responsibility to transfer technology and communicate information to the private sector. Joint DFO-private sector projects such as this one will constitute a way of transferring technology developed by DFO and information gathered from DFO research to the private sector. DFO will publish as a Technical Report a review of the data generated by this project. The purpose of this agreement is to delineate DFO's responsibilities as they relate to this particular project.

b. Methodology:

This section should contain information on:
- the names of the client's staff with whom DFO would be interacting
- how DFO would transfer technical information and advice to the client's staff

To transfer Arctic charr technology developed at the Rockwood Aquaculture Research Centre to the client, DFO will provide the client's staff with the technical information and knowledge that they require to raise Arctic charr. If required, DFO will provide these employees with training in Arctic charr husbandry techniques by having the clients' staff work at the Rockwood Aquaculture Research Centre with members of Rockwood's staff. Any and all costs associated with such training is the responsibility of the client.

The client will collect the growth, survival and feed data required to monitor and assess the performance of Arctic charr from the eyed stage to broodstock. These data will be collected at 3-month intervals (or more often if possible) during the first year of fish growth and at 4-6 month intervals thereafter. The data will be submitted on the appropriate forms (sample attached). These data will provide the basis of a Technical Report to be written by DFO with the assistance of the client.

DFO will provide the project with certified Arctic charr eggs from Rockwood Aquaculture Research Centre. The number of certified eggs provided will be dependent on the production success at Rockwood Aquaculture Research Centre. During the first year of the agreement, every effort will be made to supply 10,000 eggs. If sufficient eggs are available, the client will be provided with a maximum of 30,000 eggs per year of the agreement or per year of its renewal. DFO does not charge for materials provided under Technology Transfer. However, DFO does require clients participating in the programme to help support it by contributing to the materials for the programme. To ensure that each client's contribution is equitable, DFO has assessed programme requirements on a cost per eyed egg basis. The cost to the client will not exceed $0.05 per eyed egg. (Note: In future years, this may increase but will be a set cost for the maximum term of 3 years for each client). Costs for other sizes of live fish will be negotiated. The client will provide DFO with some commodity such as fish feed directly used in the programme.

4. PERIOD

The period of the agreement shall be until March 31, 19__. The agreement shall be renewable annually for two additional years from the spawning season at which the client first received 10,000. The renewal process shall be initiated upon the request of the client. Both parties must agree to the renewal for it to be approved.

5. TERMS AND CONDITIONS

a. It is understood and agreed that results of the pilot study will be published cooperatively by DFO and the client as a Technical Report. The client may identify economical or financial data that he/she does not want published. The client is responsible for submitting data every 4 months on survival of eggs and survival and growth of fish. The data is to be submitted on the appropriate forms (sample attached).

b. The client is solely responsible for any and all construction costs. DFO will provide only technical advice and information.

c. The client is solely responsible for any and all costs for the shipping of fish and fish eggs.

d. Eggs provided by DFO for the client are not for resale.

e. The client is responsible for the construction engineering of the project and assuring the project meets building and safety codes.

f. The agreement is not to be construed as an assignment of any rights that DFO may have to copyrights, trademarks or patents. It is further understood and agreed that if any patentable developments result from this project, the ownership of the patent(s) shall be the subject of later negotiations between the two parties of this agreement and subject to patent ownership as may be dictated by government patent regulations.

g. The client will exhibit at the site of the Pilot Project a sign indicating the participation of DFO, Central and Arctic Region in this Technology Transfer project, for the duration of the Agreement and any renewal period of the Agreement. The sign will be provided by DFO.

h. The Agreement may be terminated by either party, after demonstration of cause, and giving six months notice in writing to the other party.

i. It is understood and agreed that this agreement is a contract for the performance of services and that DFO is engaged as an independent contractor; neither DFO nor any officer, servant, or agent of DFO shall be deemed to be an employee, servant or agent of the client.

ARCTIC CHARR CULTURE

BULLETIN

NUMBER ONE ☐ JUNE 1990

APPENDIX III

Research on Arctic charr culture technology continues both at the Rockwood Aquaculture Research Centre (previously called the Rockwood Experimental Fish Hatchery), Gunton, Manitoba and the Freshwater Institute Science Laboratory, Department of Fisheries & Oceans, Central and Arctic Region, Winnipeg, Manitoba. Each year researchers learn more about Arctic charr and some of the differences between raising Arctic charr and other salmonids. Many clients in the aquaculture industry have been raising Arctic charr from 1 to 3 or 4 years and have requested information on broodstock. The following relates some information about Arctic charr broodstock which may be helpful. Other Arctic Charr Culture Bulletins will be written if we recognize a need for information in a specific area and/or as more information from our research becomes available.

STOCK DIFFERENCES

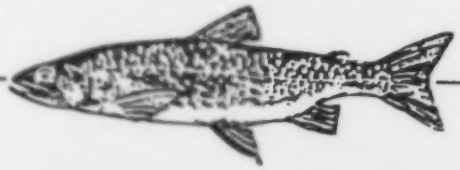
J. Tabachek and B. de March

SPAWNING PERIOD:

The stocks of Arctic charr at the Rockwood Aquaculture Research Centre come from 3 locations and each stock spawns over a different period of time:

Nauyuk Lake, N.W.T.	68° 15'N	August 21 to mid September
Norway	61° 37'N	September 21 to October 31
Labrador	56° 39'N	October 1 to early January

The Nauyuk Lake and Norwegian stocks spawn over a much shorter time period (4-6 weeks) than the Labrador stock (3 months). Most producers received eggs from the Labrador stock since it is the only certified stock of Arctic charr which is available for transfer. Temperature and photoperiod can influence the spawning period. At the Rockwood Aquaculture Research Centre, a natural Winnipeg photoperiod and low water temperatures of 7-9°C are used. For comparison, Winnipeg is at a latitude of 49° 54'N. In 1989 the spawning of all the stocks was about one month later than usual and we have no explanation for this.



Fisheries and Oceans Pêches et Océans

Canada

FECUNDITY AND EGG SURVIVAL:

For the certified Labrador (Fraser River) stock which were received as eggs in the fall of 1984, the first spawning occurred in 1987. This is the stock that has been shipped to producers across Canada.

Year	Female weight (kg)	No. of eggs		% Eyed		% Hatch		% Hatch of those eyed	
		Mean	Range	Mean	Range	Mean	Range	Mean	Range
1987	0.5-1	1950	-	50	-	28	-	63	-
1988	1-2.5	3300	1500-7500	72	0-99	60	0-96	83	6-100
1989	2-3	3900	1650-8000	35	0-97	-		-	

The reason for the decline in % eyed eggs in 1989 is still under investigation.

The Nauyuk Lake stock of Arctic charr produces fewer eggs than the Labrador stock. While the Labrador stock produces 3000-4000 or more eggs, the Nauyuk Lake stock generally produces 1200-2200 eggs. This is typical of what happens in the wild with both stocks. The Norwegian stock produces about 3000 eggs. Under hatchery conditions, the Labrador and Norwegian charr start to spawn at 3 years of age, the Nauyuk Lake stock do not start to spawn until at least 4 years of age and most first spawn at 5-6 years of age.

OTHER DIFFERENCES:

In physical appearance, the most conspicuous differences between the three stocks of Arctic charr at the Rockwood Aquaculture Research Centre are between the Norwegian and the Canadian (Nauyuk Lake and Labrador) stocks. The Norwegian stock has more black pigmentation and a more muscular appearance. There is greater variation in the growth rate of the Norwegian stock although this may not increase with time as much as in the Canadian stocks.

The Norwegian stock grows more slowly and is smaller at maturity than the Nauyuk Lake or Labrador stocks. The Norwegian stock never reaches the larger adult sizes that the Canadian stocks do. "Hybrid vigour" does not seem to occur when the Nauyuk Lake charr are crossed with the Norwegian charr. The offspring seem to be intermediate in size and colouration and the hybrid populations may in fact have more size variation than the pure strains.

The Norwegian stock produces smaller eggs and thus smaller fry than the Canadian stocks. Although the hatchability of the Norwegian stock has been higher than that of the Canadian stock, there is higher mortality at first-feeding with the Norwegian stock. This can be reduced by increasing the water temperature to 10°C at first-feeding.

PHOTOPERIOD
B. de March

Wild Arctic charr populations experience strong seasonal changes which are important in the timing of events such as maturation and spawning. There are many reasons to believe that this is important to the health and management of broodstock. Unfortunately, a "formula" approach that ensures synchronized maturation has not been developed yet.

Presently, most hatchery broodstock are maintained at a Winnipeg photoperiod, which reaches a maximum of 16 hours light in June and a minimum of 8 hours light in December. After approximately 8 years, all stocks still spawn in the fall. We also know that fish kept under artificial summer conditions all winter will not spawn well the next fall. With the Winnipeg photoperiod, the stock from the coldest northerly location, Nauyuk Lake (68°N), spawns earliest and the Norwegian stock, from the same latitude but a warmer climate, spawns later. Both of these stocks experience 24 hours light and 24 hours dark for several weeks each year in their natural habitat. The stock from Labrador, Canada (57°N), which experiences a maximum of 19 hours light and many hours of dawn and dusk in its natural habitat, spawns the latest. It appears that the fish from the most severe climates respond most strongly to the changes in our hatchery. We will attempt to manipulate spawning this year by using this knowledge.

One approach that has worked at the Rockwood Aquaculture Research Centre is as follows:
1) Maintain fish on a Winnipeg photoperiod until their demand for food decreases, which will probably be at spawning (late fall to December).
2) Maintain this low daylength and/or impose colder temperatures (6°C in our case) for several months.
3) When fish start to feed actively again (in our case, mid-April), return to the normal Winnipeg photoperiod and growth-promoting temperatures.

We still do not know whether the cues that reset the "biological clocks" for the development of eggs and/or spawning are short or long daylength, or cold or warm temperatures. At this point, imitating a natural year, even if in segments may be the best approach.

SELECTION AND CULLING OF BROODSTOCK
B. de March

When maintaining broodstock, producers and researchers are faced with the somewhat opposing objectives of selecting for and maintaining the largest and healthiest fish, and at the same time, maintaining some genetic diversity. If we simply select the largest fish from a tank, we may discover that they all are siblings and inbreeding problems may arise in later years. If we "mass fertilize" eggs, that is, mix all eggs and milt in one container, we may discover that one male is responsible for all the fertilized eggs, and the same inbreeding problems may arise in the future.

For non-experimental work, staff at the Rockwood Aquaculture Research Centre now do only one-to-one crosses (or at most two-to-one) when working with broodstock. That is, each female is crossed with one male (maximum two males) and many such crosses are made. This gives all individuals in the population an equal chance to contribute to the gene pool. These individual crosses or families are incubated separately. You can put plexiglass dividers in a Heath tray to keep each family separate. At some point after eyeing, the same volume or number of eyed eggs are taken from each family and pooled to form the future brood stock. An alternate but less ideal way would be to incubate an equal number of eggs from each cross right from the start in an undivided Heath tray.

There are several problems associated with culling fish. If fish are culled sometime after the onset of maturation, but the sex of the fish is not yet evident (for example 2-year olds), we may discover that most of the selected animals are of the same sex. When culling two-year olds, I have taken the following approach: 1) I decide how many animals I want to keep, 2) I pick one half of these from the largest fish in the tank, 3) I pick the other half as the most colourful fish in the tank. I seem to have maintained a fairly good sex ratio, biased slightly towards more females by using this approach.

ALTERNATE YEAR SPAWNERS
J. Tabachek and B. de March

We have evidence now that some females may be alternate year spawners. That is, some females do not produce eggs every year. We do not have enough information yet to determine if this occurs in all stocks or what proportion of the female population is expected to be alternate year spawners. This can also occur in the wild so we should not be surprised if all the females do not produce eggs every year. At this point, all we can do is advise you that this may occur. We recommend that you do as we have done and tag your fish so that you can follow the progress of each fish individually.

In the years that females do not spawn they can be very skinny. If these are culled as "inferior" fish, next year's broodstock may be destroyed. Until we can define conditions that ensure that females spawn every year or can select for those individuals that spawn every year, it is probably a good idea to cull very conservatively after animals have reached sexual maturity.

FREQUENCY OF SPAWNING CHECKS
J. Tabachek

Once the female ovulates, the eggs can be stripped and fertilized. Research with the Nauyuk Lake stock of Arctic charr indicated that the eggs over-ripen very quickly once ovulation has occurred (Krieger et al. 1988. Bull. Aquacult. Assoc. Can. 88-4:34-36). If eggs were stripped and fertilized within 4-7 days after ovulation, there was only a minor reduction in % eyed or hatched. However, if 11-14 days passed before the eggs were stripped, then the % eyed and % hatched declined markedly. Therefore, it is recommended that Arctic charr broodstock be examined at least every 7 days. Rainbow trout eggs over-ripen less quickly and it has been recommended that rainbow trout broodstock be examined at least every 10-14 days to achieve optimal survival.

SPAWNING TECHNIQUES
R. Olson

ESTABLISHING THE SEX OF A FISH:

Establishing the sex of Arctic charr by visual inspection is virtually impossible until the fish reach three years of age. At age three, as first spawning approaches, some differences between males and females may be observed:

- bodies of the males may become more slender those of the females. Even before egg development, females becomes obvious.
- colouration of the males may be brighter than that of the females, especially the under-bellies, which may become yellow or orange in colour. Note: if pigmented feeds are used, charr will be red-orange.
- snouts of males may become more pointed and many will begin to develop a kype.
- snouts of the males may also become a lighter brownish color when viewed from above, unlike the females.

Most of these characteristics will become more obvious as the spawning time approaches and less obvious after spawning is complete. Therefore, at spawning time, it would be wise to tag the fish, using one colour tag for males and another for females.

We have been fooled by charr - especially in believing that some fish were females. We have had some Labrador charr (especially large silvery ones) with absolutely no physical signs of being male until they were 5 years old. Then, they developed a kype and male colouration and produced milt for the first time at 5 years of age - 1-2 years later than others in the population.

FEEDING DURING THE SPAWNING PERIOD:

Past spawning records of the stock will indicate the approximate time when spawning can be expected to start. A decline in feeding activity is also a good indication that the fish are approaching spawning time. We usually begin to check our brood stock at 10 day intervals at least 3-4 weeks before this date. When some females appear to be very well developed, and are estimated to be very close to spawning (1 week), we stop all feeding to that group of fish. This allows adequate time for the fish to be "cleaned out". If feces are expelled into the spawning pan during spawning, fertilization will be reduced drastically. If tank space is available to hold spawned out fish, these can be held separately and fed lightly. After one month, if some fish have not spawned, they can be fed lightly the day after their weekly spawning check.

SPAWNING METHOD:

Ripe females should be sorted out in advance along with enough males to use with them. The ratio of females to males will depend on the planned use of the offspring:

- if mass egg production is required to produce market fish, then as many as 4 or 5 females could be spawned at one time into the spawning pan (provided no water is allowed to enter the pan during spawning). The eggs in each pan could be fertilized with 3 or 4 males.
- if egg production is required to produce future brood stock, then one female should be spawned at a time and fertilized with 1 or 2 males (as described in "Selection of Brood Stock") and egg groups held separately.

Materials required: - wool mitts to wear when handling the fish, spawning pan, dry cloths, small container for milt, feather, container of fresh water for fertilization, lots of fresh water for rinsing.

Procedure:

- Anesthetize fish to be spawned (we use phenoxyethanol 0.25 ml/litre water) until they can be handled without movement - anaesthetize only enough fish at one time to do one pan of eggs.
- Dry spawning pan with cloth before spawning.
- Dry underside and tails of all fish immediately before spawning. Any water contacting the eggs before fertilization will cause the micropyle of the egg to close prematurely and prevent fertilization.
- Spawn eggs from female(s) into pan ensuring that no water enters the pan.

- Spawn the milt from a male into pan. If more than one male is being used, combine the milt from the males in a separate container (with absolutely no water in the container) before adding it to the pan of eggs.
- Use a feather to stir the milt into the eggs and distribute it evenly throughout the eggs.
- Add only enough fresh water to completely cover the eggs (more water will only dilute the milt). Stir slowly and gently for one minute, then every 15-30 seconds after that for another minute.
- At this time all fertilization should be complete. Eggs in the pan should be rinsed with fresh water until they are clean. Timing here is very important. Approximately 10-15 minutes after fertilization, the eggs will begin to water harden. During hardening they will be extremely delicate. We try to put the eggs in an incubator or some temporary container within 10 minutes (maximum 15 minutes) where they will not be disturbed for two hours. After 2 hours, they are no longer delicate and for approximately 48 hours they can be moved (or shipped) to the location where they will be incubated. After 48 hours they become very delicate again and should not be disturbed for any reason until they are eyed. During this time, regular formalin treatments may be used to prevent the growth of fungus.

Other fish culturists will probably have variations to this method. However, this method works well at the Rockwood Aquaculture Research Centre and we believe if both the eggs and milt are good, very high survival rates are possible.

IMPORTANCE OF REMOVING OLD EGGS

J. Tabachek

If eggs are not removed from the female, then the contents of the eggs will gradually be resorbed but the shells will remain. We have found that if old eggs are not removed from the female charr, the old shells will form a "plug". The following year, this plug will make it very difficult to allow eggs to be released. You will find that the female will be ripe and bulging with eggs but you will not be able to release them. Sometimes, you will examine a female for a period of several weeks and try to release these eggs. When you finally dislodge the plug of old shells and the eggs are finally released, they will be over-ripe and will have very low chance of being fertilized. Therefore, it is very important to examine all the fish and remove all the old eggs. You may find that a small proportion of the females may produce eggs at 3 years and it is important to remove these eggs. In addition, since 10% of the eggs will probably remain in the female after spawning, all females should be examined at least once or twice after spawning to remove the remaining eggs.

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